NATURAL RESOURCES CONSERVATION SERVICE

VIRGINIA CONSERVATION PRACTICE STANDARD

TERRACE

(Ft, m)

CODE 600

DEFINITION

An earth embankment, or a combination ridge and channel, constructed across the field slope.

PURPOSE

This practice may be applied as part of a resource management system to support one or both of the following:

- Reduce soil erosion
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion by water is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and farmed with reasonable effort
- A suitable outlet can be provided
- Excess runoff is a problem

CRITERIA

GENERAL CRITERIA APPLICABLE TO ALL PURPOSES

Terraces shall be planned, designed, and constructed to comply with all federal, state, and local laws and regulations.

Spacing

The maximum spacing for terraces for erosion control shall be determined by use of one of the following methods:

1. **V.I. = xs + y** or **H.I. = (xs + y) (100/s)**

Where:

V.I. = vertical interval in feet (m)

H.I. = horizontal interval in feet (m)
(See Figures 2 and 3)

x = a variable with values from 0.4 to 0.8 (0.12 to 0.24) (See Figure 1)

s = land slope in percent

y = a variable with values from 1.0 to 4.0 (0.3 to 1.2)

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Values of x for different geographical zones are shown in Figure 1. Values of y are influenced by soil erodibility, cropping system and crop management practices. A value of 1.0 (0.3) shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 (1.2) shall be used for erosion-resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre or 3.4 metric tons per hectare) on the surface. A value of 2.5 (0.75) shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 (0.3) and 4.0 (1.2) may be used according to the estimated quality of the factors. The horizontal spacing does not have to be less than 90 feet.

2. **Revised Universal Soil Loss Equation**

(RUSLE). The spacing shall not exceed the critical slope length as determined using RUSLE. When tables are used to calculate critical slope, refer to Table 1 of this standard for terrace P factor. Soil loss in the inter-terrace interval must be less than or equal to the allowable soil loss.

In no case shall the maximum horizontal spacing exceed that shown in Table 2 for the condition shown. The maximum limits may not be exceeded when making adjustments indicated below.

Spacing may be increased as much as 10 percent to provide better location or alignment, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased as much as additional 10 percent for terraces with underground outlets. The spacing shall be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths.

The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval. For example, use the proposed as-built slope and length in RUSLE calculations.

For level terraces used for erosion control and water conservation, the spacing shall be determined as previously described, but in no case shall the maximum horizontal spacing exceed 600 ft (180 m). An x value of 0.8 (0.24) may be used for all level terraces used primarily to impound water. When using the V.I. or H.I. spacing method, Figures 2 and 3 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 4).

For terraces on non-cropland, the maximum spacing shall be governed by the capacity requirement.

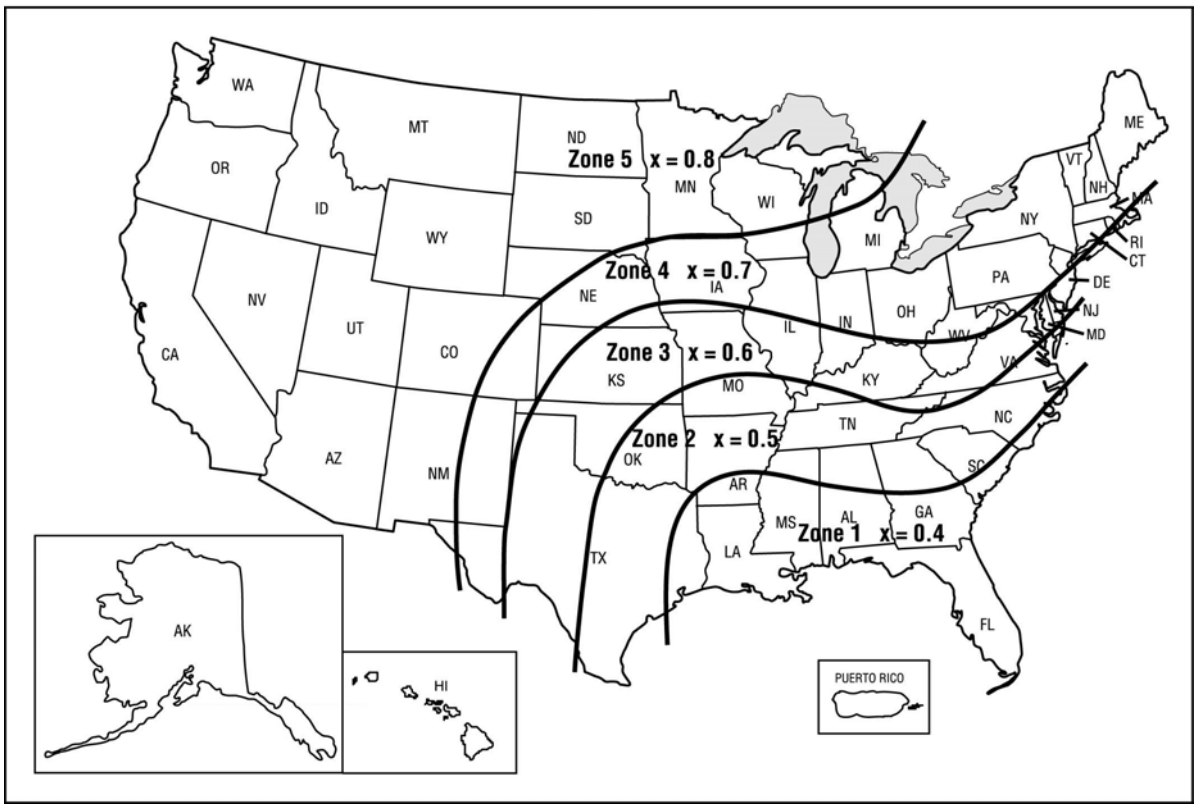

Figure 1. Values of x in equation V.I. = xs + y or H.I. = (xs + y) (100/s)

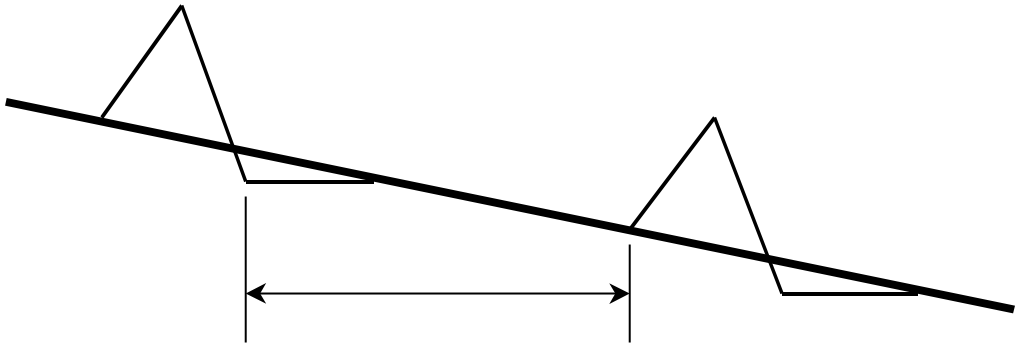

Figure 2. Horizontal Interval for Steep Back-slope Terraces

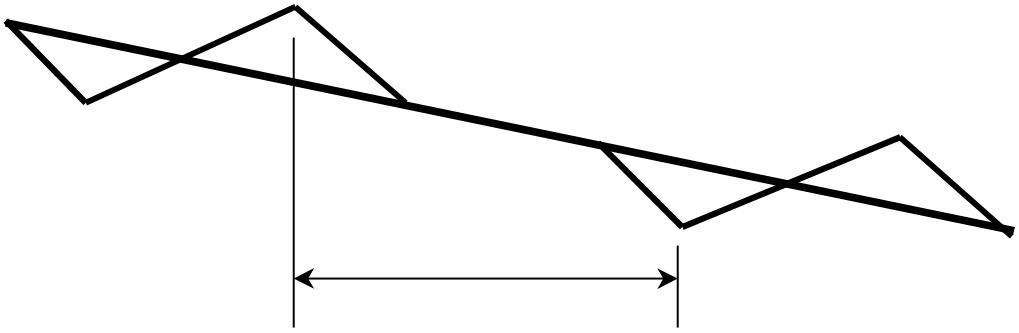

Figure 3. Horizontal Interval for Broad-Based Terraces

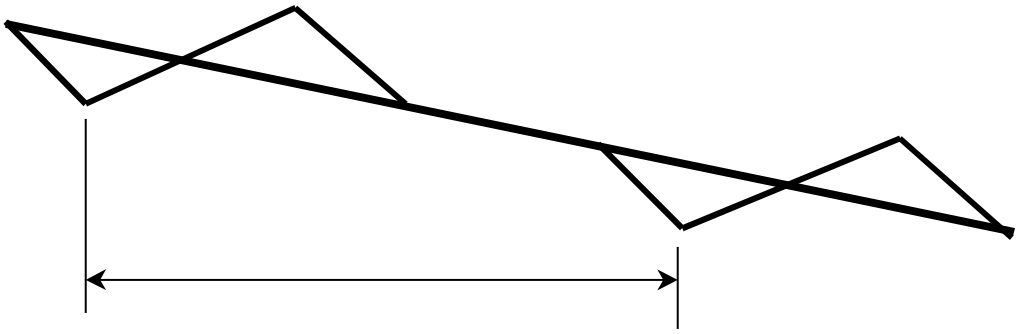

Figure 4. Terrace Spacing

Table 1. Terrace P factors [1]

Horizontal Interval		Closed Outlets [2]	Open outlets with percent grade of: [3]		
(ft)	(m)		0.1 - 0.3	0.4 - 0.7	0.8
Less than 110	Less than 33	0.5	0.6	0.7	1.0
110-140	33-42	0.6	0.7	0.8	1.0
140-180	43-54	0.7	0.8	0.9	1.0
180-225	55-68	0.8	0.8	0.9	1.0
225-300	68-90	0.9	0.9	1.0	1.0
More than 300	More than 90	1.0	1.0	1.0	1.0

NOTE: If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1 These figures are not appropriate for sediment yield estimates.

2 "P" factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

3 The channel grade is measured on the 300 ft. of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less

Table 2. Maximum horizontal spacing for terraces

	RUSLE R Factor of						With Contour Stripcropping		For Concentrated Flow Control	
	0 - 35		35 - 175		> 175					
Percent Slope	Ft	M	Ft	M	Ft	M	Ft	M	Ft	M
0-2	700	210	500	150	450	130	600	180	700	210
2-4	700	210	400	120	300	90	600	180	700	210
4-6	600	180	400	120	200	60	600	180	600	180
6-9	400	120	300	90	150	45	400	120	500	150
9-12	400	120	250	75	150	45	250	75	500	150
12-18	250	75	200	60	150	45	150	45	400	120
> 18	250	75	200	60	150	45	150	45	300	90
Minimum spacing required, all slopes	200	60	150	45	90	27	90	27	200	60

Alignment

Cropland terraces shall be parallel if feasible and as parallel as practicable. Curves shall be long and gentle to accommodate farm machinery. Land forming, extra cut fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods shall be used to achieve good alignment.

Field efficiency may be used to compare alternative terrace systems. Field efficiency is the ratio of time required to farm the field being planned, to that required to farm a rectangular field of the same acreage ½ mile long.

Capacity

The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with

underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless sediment is removed through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have the appropriate design capacity. When the capacity is determined by the formula Q = AV and the V is calculated using Manning's formula, a minimum n value of 0.035 shall be used for bare channels. Agricultural Handbook Number 667, Stability Design of Grass-lined Open Channels, or equivalent shall be used for vegetated channels.

Cross Section

The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety.

The ridge shall have a minimum width of 3 ft. (1 m) at the design elevation. The steepest slope of a vegetated front or back ridge slope is 2 horizontal:1 vertical. Terrace ridges, especially those with steep back slopes, can be very hazardous. All cropped terrace slopes that are to be farmed shall be no steeper than those on which farm equipment can operated safely. Potential hazards must be brought to the attention of the responsible person.

The cross sectional area of the terrace channel for gradient terraces shall not be less than eight (8) square feet for land slopes of 5 percent or less, seven (7) square feet for land slopes from 5 to 8 percent, and six (6) square feet for land slopes steeper than 8 percent. The cross section may be increased to improve the farmability with large equipment.

The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

End Closures

Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures shall be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water flows over the end closure before overtopping the terrace ridge. Partial end closures shall not be more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

Channel grade

Channel grade shall be determined by one of the following methods:

1. Maximum channel grade in the lower reaches of the channel shall not exceed 0.6 percent.

2. Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

3. Maximum channel velocity for cultivated channels shall be nonerosive for the soil and planned treatment. Maximum velocity for erosion-resistant soils is 2.5 ft/s (0.75 m/s); for average soils, 2.0 ft/s (0.6 m/s); and for easily erodible soils, 1.5 ft/s (0.45 m/s). Velocity shall be computed by Manning's formula, using a maximum n value of 0.035.

Channel grades may be uniform or variable. Channel velocity shall not exceed that which is non-erosive for the soil and planned treatment.

The maximum channel grade for the terrace channel shall be 1.5 (V) feet per 100 (H) feet (1.5%) for the upper 200 feet of terrace length. Where necessary to improve alignment and make adjacent terraces parallel, grades in excess of 0.6 (V) feet per 100 (H) feet (0.6%) may be used for short distances, provided they do not result in erosive velocities. Channels will be permanently vegetated, if necessary, to control erosion, when maximum channel grades or velocities are exceeded.

For short distances and in upper reaches, channel grades or velocities may be increased to improve

alignment. If terraces have an underground outlet, water and sediment will pond in the lower reaches of the channel, thus reducing the velocity in those reaches and allowing steeper channel grades within the impoundment area. Minimum grades shall be such that ponding in the channel caused by minor irregularities will not cause serious damage to crops or delay field operations.

Terrace Length

The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft. (1,000 m) unless the channel is blocked at intervals not exceeding 3,500 ft. (1,000 m). Normally, the capacity and the nonerosive velocity requirements will control the gradient terrace length. Two thousand (2000) feet is generally considered the maximum length of a gradient terrace.

Outlets

All terraces must have adequate outlets. Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or other vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets shall be installed and vegetation established before the terrace is constructed if necessary to provide a stable outlet. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. An orifice plate, increase in conduit size, or other features shall be installed as needed to control the release rate and prevent excessive pressure in the conduit when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, shall be such that a 10-year frequency, 24-hour storm will not overtop the terrace, and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops, depending on soils characteristics and water tolerance of crops to be grown. If sediment retention is desired, adjust release rate according to particle size.

The underground conduit shall meet the requirements specified in Virginia Conservation Practice Standards *Underground Outlets (Code 620)* or *Subsurface Drains (Code 606)*. Conduits must be installed deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe or other structure suitable for the intended purpose. The inlet shall be located uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel within a reasonable period so standing water does not significantly damage crops.

Combinations of different types of outlets may be used on the same system to maximize water conservation, to improve water quality, and to provide for economical installation of a more farmable system.

Vegetation

All areas to be vegetated shall be established as soon as practicable after construction.

Drainage

Install subsurface drainage to stabilize terrace where needed. It shall be designed taking into consideration the effect of snowcatch and melt on water budget components.

Roads

Field roads may be located to enhance the farmability of the terrace system and gain access to the field. They may be located on the edge (toe) of the back slope of the terrace or on ridges where sharp changes in terrace direction would occur.

Roads may also be located in correction intervals where they serve as a turn area for short rows. Grassed turn strips at the field edge and grassed odd areas will enhance farmability and reduce nutrient and pesticide runoff if properly located.

ADDITIONAL CRITERIA APPLICABLE TO RETAINING RUNOFF FOR MOISTURE CONTROL

Terrace capacity shall be designed in accordance with a water budget analysis.

SPECIAL CRITERIA FOR SHORT TERRACES

The purpose of this special criteria is to provide an alternative design for terraces constructed on small irregular fields. The design and construction of these terraces shall be in accordance with all the other provisions of this Virginia Conservation Practice Standard *Terrace (Code 600)*, except as follows:

Conditions Where This Criteria Applies:

1. Terraces do not convey water more than 400 feet from crest to outlet.

2. Topography is such that it is not practical to construct terraces with ridge widths greater than two (2) feet.

3. Special attention is given to maintaining the terrace ridge at the design width and height.

Design Criteria

1. The ridge shall have a minimum width of two (2) feet at the design flow elevation.

2. The minimum cross sectional area of the terrace channel shall have enough capacity to control the peak discharge from a 10 year-24 hour storm without overtopping.

CONSTRUCTION CRITERIA

All dead furrows, ditches, or gullies shall be filled before constructing the terrace or shall be part of the construction. All old terraces, fencerows, hedgerows, trees, and other obstructions shall be removed, as necessary, to install a farmable system.

The terraces shall be constructed according to planned alignment, grade, and cross section with the specified overfill for settlement and the channel graded to drain reasonably well.

Any ditch or depression at the bottom of the back slope shall be filled and smoothed so that drainage will be away from the terrace and not parallel to us.

Provisions must be made to prevent piping if underground circuits are located under terrace ridges. Mechanical compaction, water packing, trench sidewall sloping, and installation and backfill of conduit trenches early enough to allow adequate settlement are methods that can be used. The materials used for the inlet and the conduit shall be suitable for the purpose intended (See Virginia Conservation Practice Standard *Subsurface Drain [Code 606]).* Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or by other suitable means to ensure proper functioning of the terrace.

The surface of the finished terrace shall be reasonably smooth and present a workmanlike finish.

If necessary, topsoil shall be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

If vegetation is required, seedbed preparation, fertilizing, seeding, and mulching shall comply with specifications in the *Plant Establishment Guide for Virginia*.

CONSIDERATIONS

Consider aligning terraces and/or installing subsurface drainage to correct seepage problems.

Considerations should be given to:

- Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

- Variability effects caused by seasonal or climatic changes.
- Effects of snowcatch and melt on water budget components.
- Potential for a change in plant growth and transpiration because of changes in the volume of soil water.
- Effects on the downstream or acquifers that could affect other water uses and users.
- The effect on the water table of the field to ensure that it will provide a suitable rooting depth, field wide, for anticipated landuses.
- Potential for water management to supply alternate uses.
- Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.
- Effects of nutrients and pesticides on surface and groundwater quality.
- Effects on the visual quality of onsite and downstream water.
- Short-term and construction-related effects on the quality of onsite and downstream water.
- Potential for development of saline seeps or other salinity problems resulting from increased infiltration in soils that have restrictive layers.
- Potential for uncovering or redistributing toxic materials such as saline soils.
- Effects on the movement of dissolved substances below the root zone and to the groundwater.
- Effects on wetlands and water-related wildlife habitats.

PLANS AND SPECIFICATIONS

Plans and specifications for installing terraces shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

DESIGN DATA

Record the following layout and design information:

1. Location Sketch – name of person doing survey and design.
2. Terrace number and direction of flow (show in a sketch)
3. Average land slope, cross section, capacity and velocity for each terrace.
4. Horizontal or vertical interval for each terrace.
5. Staked length in feet of each terrace (paced).
6. Environmental Evaluation Form VA-EE-1.

Location and requirement of needed waterways and outlets will be shown.

All field notes will be recorded in a standard engineering field book, or on terrace design sheets.

CHECK DATA

Check a minimum of one terrace per field. The terrace selected should be the one that appears least likely to meet specifications.

1. Profile of the channel and ridge.
2. Cross section of channel and ridge for the same terrace as shown above.
3. Compute channel cross sectional area and record.
4. Record the length of <u>each</u> completed terrace.
5. Include statement as to adequacy of outlet.
6. Provide data and signature of person making construction check.

OPERATION AND MAINTENANCE

Operation and maintenance requirements shall be prepared for the operator.
The minimum requirements to be addressed are:

1. Provide periodic inspections, especially immediately following runoff events.

2. Promptly repair or replace damaged components as necessary.

3. Maintain terrace ridge height and outlet elevations.

4. Remove sediment that has accumulated in the terrace to maintain capacity, a positive channel grade, and to maintain capacity where soil infiltration serves as the outlet.

5. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

6. Vegetation, where specified, shall be maintained and trees and brush controlled by chemical or mechanical means.

7. Vegetated outlets should be established before construction when feasible.

8. Keep machinery away from steep back sloped terraces. Keep equipment operators informed of all potential hazards.

REFERENCES

1. NRCS, Virginia Field Office Technical Guide, Section IV.

2. Engineering Field Handbook, National Engineering Handbook, Part 650, Chapters 2 and 8), USDA, SCS.

3. Agricultural Handbook No. 537, Predicting Rainfall Erosion Losses.

4. *Plant Establishment Guide for Virginia*.

NATURAL RESOURCES CONSERVATION SERVICE

VIRGINIA CONSERVATION PRACTICE STANDARD

TERRACE

Approved Practice Narratives

(Ft, m)

CODE 600

600 D1 Terrace: Install gradient terraces.

600 D2 Terrace: Install underground outlet terraces.

NRCS, VA, August 2003